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U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

**TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371**

032326-165

U.S. APPLICATION NO. (if known, see 37 C.F.R. 1.51)

Unassigned

PRIORITY DATE CLAIMED
8 March 1999INTERNATIONAL APPLICATION NO.
PCT/FR00/00283INTERNATIONAL FILING DATE
7 February 2000

TITLE OF INVENTION

COUNTERMEASURE METHOD IN AN ELECTRIC COMPONENT USING A SECRET KEY CRYPTOGRAPHIC ALGORITHM

APPLICANT(S) FOR DO/EO/US
Olivier BENOIT

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
 2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
 3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and the PCT Articles 22 and 39(1).
 4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
 5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☒ has been transmitted by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
 6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
 7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
 - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ have been transmitted by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has **NOT** expired.
 - d. ☒ have not been made and will not be made.
 8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
 9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
 10. ☒ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).
- Items 11. to 16. below concern other document(s) or information included:**
11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
 12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
 13. ☒ A **FIRST** preliminary amendment.
 - ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
 14. ☐ A substitute specification.
 15. ☐ A change of power of attorney and/or address letter.
 16. ☐ Other items or information:

U.S. APPLICATION NO. (if known) 097936208 Unassigned		INTERNATIONAL APPLICATION NO. PCT/FR00/00283		ATTORNEY'S DOCKET NUMBER 032326-165	
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17. <input checked="" type="checkbox"/> The following fees are submitted:				CALCULATIONS		PTD USE ONLY	
Basic National Fee (37 CFR 1.492(a)(1)-(5)): Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO \$1,000.00 (960) International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO \$860.00 (970) International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International search fee (37 CFR 1.445(a)(2)) paid to USPTO \$710.00 (958) International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$690.00 (956) International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) \$100.00 (962)				ENTER APPROPRIATE BASIC FEE AMOUNT = \$ 860.00			
Surcharge of \$130.00 (154) for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492(e)). 20 <input type="checkbox"/> 30 <input type="checkbox"/>						\$ -0-	
Claims	Number Filed	Number Extra	Rate				
Total Claims	8 -20 =	-0-	X\$18.00 (966)			\$ -0-	
Independent Claims	2 -3 =	-0-	X\$80.00 (964)			\$ -0-	
Multiple dependent claim(s) (if applicable)				+ \$270.00 (968)		\$ -0-	
TOTAL OF ABOVE CALCULATIONS =						\$ 860.00	
Reduction for 1/2 for filing by small entity, if applicable (see below).						\$ -0-	
SUBTOTAL =						\$ 860.00	
Processing fee of \$130.00 (156) for furnishing the English translation later than months from the earliest claimed priority date (37 CFR 1.492(f)).				20 <input type="checkbox"/> 30 <input type="checkbox"/>		\$ -0-	
				+			
TOTAL NATIONAL FEE =						\$ -0-	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 (581) per property +						\$ -0-	
TOTAL FEES ENCLOSED =						\$ 860.00	
						Amount to be refunded	\$
						charged	\$

a. ☐ Small entity status is hereby claimed.

b. ☒ A check in the amount of \$ 860.00 to cover the above fees is enclosed.


c. ☐ Please charge my Deposit Account No. 02-4800 in the amount of \$_____ to cover the above fees. A duplicate copy of this sheet is enclosed.

d. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 02-4800. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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 SIGNATURE

 James A. LaBarre
 NAME

28,632
 REGISTRATION NUMBER

Patent
Attorney's Docket No. 032326-165

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of)	
)	
Olivier BENOIT)	Group Art Unit: Unassigned
)	
Application No.: Unassigned)	Examiner: Unassigned
)	
Filed: September 10, 2001)	
)	
For: COUNTERMEASURE METHOD IN)	
AN ELECTRIC COMPONENT)	
USING A SECRET KEY)	
CRYPTOGRAPHIC ALGORITHM)	

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to examination and the calculation of filing fees, kindly amend the above-identified application as follows:

IN THE SPECIFICATION:

Page 1, immediately following the title appearing on lines 1 and 2, insert the following:

--This disclosure is based upon, and claims priority from French Application No. 99/02834, filed on March 8, 1999 and International Application No. PCT/FR00/00283, filed February 7, 2000, which was published on September 14, 2000 in a language other than English, the contents of which are incorporated herein by reference.

Background of the Invention--

Page 8, between lines 15 and 16, insert the following heading:

--Summary of the Invention--

Page 12, before line 8, insert the following heading:

--Brief Description of the Drawings--

Page 13, before line 7, insert the following heading:

--Detailed Description--

Add the following Abstract:

--An electronic component uses a secret key cryptographic algorithm that employs several successive computing cycles to supply final output data from initial input data applied at the first cycle. A first random value is applied to a computation conducted for each cycle, to obtain unpredictable output data. A second random value as also applied to the initial input data that is used for the input of the first cycle.--

IN THE CLAIMS:

Kindly replace claims 1-7, as follows.

1. (Amended) A countermeasure method against attacks by differential analysis in an electronic component implementing a secret key cryptographic algorithm, the implementation of which comprises a number of successive calculation cycles in order to supply, from first input data applied to the first cycle, final data at the output of the last

cycle to produce an encrypted message, each calculation cycle using calculation means for supplying an output data item from an input data item, said calculation means performing the steps of:

applying a first random value to the input data item and to the output data item in order to obtain an unpredictable data item as an output, and

applying a second random value to said first input data by means of an EXCLUSIVE OR operation.

2. (Amended) A countermeasure method according to Claim 1, further including the step of applying the second random value to the final data supplied by the last cycle by means of an EXCLUSIVE OR operation.

3. (Amended) A countermeasure method according to claim 1 further including the step, at the end of each cycle, of executing an additional operation to eliminate said first random value at the output of each cycle.

4. (Amended) A countermeasure method according to claim 1 wherein a new set of first and second random values is selected for each new execution of the algorithm.

5. (Amended) A method according to Claim 4, wherein said calculation means are calculated from first calculation means defining, for input data, corresponding output

data, by applying the second random value to said input data and applying the first random value at least to said output data of the first calculation means.

6. (Amended) A countermeasure method according to Claim 5, wherein the calculation means comprise constants tables.


7. (Amended) An electronic security component that implements a countermeasure method for attacks against a secret key cryptographic algorithm by means of differential analysis, wherein said algorithm comprises a number of successive calculation cycles in order to supply, from first input data applied to the first cycle, final data at the output of the last cycle to produce an encrypted message, each calculation cycle using calculation means for supplying an output data item from an input data item, said calculation means comprising the application of a first random value to the input data item and to the output data item to obtain an unpredictable output data item, comprising first calculation means fixed in a program memory, second calculation means that are calculated at each new execution of the algorithm and stored in working memory, and means for generating first and second random values for calculating said second calculation means.

REMARKS

Entry of the foregoing amendment is respectfully requested. This amendment is intended to place the claims in a more conventional format and eliminate the multiple dependency of the claims.

Respectfully submitted,

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Date: September 10, 2001

Attachment to Preliminary Amendment dated September 10, 2001

Marked-up Claims 1-7

1. (Amended) A countermeasure method against attacks by differential analysis in an electronic component implementing a secret key [(K)] cryptographic algorithm, the implementation of which comprises a number of successive calculation cycles [(T1, ... T16)] in order to supply, from first input data [(L0, R0)] applied to the first cycle [(T1)], final data [(L16, R16)] at the output of the last cycle [(T16) allowing the production of] to produce an encrypted message [(C)], each calculation cycle using calculation means [(TC)] for supplying an output data item [(S)] from an input data item [(E)], said calculation means [comprising the application of] performing the steps of:

applying a first random value [(u)] to the input data item [(E)] and to the output data item [(S)] in order to obtain [at the output] an unpredictable data item [(S⊕u), characterised in that the method comprises the use of means of] as an output, and

applying a second random value [(v)] to said first input data [(L0, R0), according to] by means of an EXCLUSIVE OR operation.

2. (Amended) A countermeasure method according to Claim 1, [characterised in that it also comprises the use of means] further including the step of applying the second random value [(v)] to the final data supplied by the last cycle [(T16), according to] by means of an EXCLUSIVE OR operation.

Attachment to Preliminary Amendment dated September 10, 2001

Marked-up Claims 1-7

3. (Amended) A countermeasure method according to [either one of the previous claims, characterised in that it comprises] claim 1 further including the step, at the end of each cycle, [the execution] of executing an additional operation [(CP(p(u))) in order] to eliminate said first random value [(u)] at the output of each cycle.

4. (Amended) A countermeasure method according to [any one of the previous claims, characterised in that it comprises the taking of] claim 1 wherein a new set of first and second random values [(u, v) and calculation of the calculation means (TC_M) used in each cycle] is selected for each new execution of the algorithm.

5. (Amended) A method according to Claim 4, [characterised in that] wherein said calculation means [(TC_M)] are calculated from first calculation means [(TC₀)] defining, for input data [(E)], corresponding output data [(S)], by applying the second random value [(v)] to said input data [(E⊕e(v))] and applying the first random value [(u)] at least to said output data [(S⊕u)] of the first calculation means.

6. (Amended) A countermeasure method according to Claim 5, [characterised in that] wherein the calculation means [(TC₀, TC_M)] are comprise constants tables.

Attachment to Preliminary Amendment dated September 10, 2001

Marked-up Claims 1-7

7. (Amended) An electronic security component [implementing the] that implements a countermeasure method [against attacks by differential analysis comprising] for attacks against a secret key [(K)] cryptographic algorithm[, the implementation of which] by means of differential analysis, wherein said algorithm comprises a number of successive calculation cycles [(T1, ... T16)] in order to supply, from first input data [(L0, R0)] applied to the first cycle [(T1)], final data [(L16, R16)] at the output of the last cycle [(T16)] allowing the production of] to produce an encrypted message [(C)], each calculation cycle using calculation means [(TC)] for supplying an output data item [(S)] from an input data item [(E)], said calculation means comprising the application of a first random value [(u)] to the input data item [(E)] and to the output data item [(S)] in order] to obtain [at the output] an unpredictable output data item [(S⊕u), characterised in that], comprising first calculation means [(TC₀) are] fixed in a program memory [(1) of said component], second calculation means [(TC_M) used in each cycle being] that are calculated at each new execution of the algorithm and stored in working memory [(3)], and [in that it comprises] means [(4) of] for generating first and second random values [(u, v)] for calculating said second calculation means [(TC_M)].

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COUNTERMEASURE METHOD IN AN ELECTRONIC COMPONENT
IMPLEMENTING A SECRET KEY CRYPTOGRAPHIC ALGORITHM

The present invention relates to a countermeasure method in an electronic component implementing a secret key cryptographic algorithm. They are used in applications where the access to services or data is strictly controlled. They have an architecture formed around a microprocessor and memories, one of which is a program memory which contains the secret key.

These components are notably used in smart cards, for certain applications thereof. These are for example applications for accessing certain data banks, banking applications, or remote payment applications, for example for television, petrol dispensing or passing through motorway tolls.

These components or these cards therefore implement a secret key cryptographic algorithm, the best known of which is the DES (Data Encryption Standard) algorithm. Other secret key algorithms exist, such as the RC5 algorithm or the COMPl28 algorithm. This list is of course not exhaustive.

Briefly and in general terms, the function of these algorithms is to calculate an encrypted message from a message applied at the input (to the card) by a host system (server, cash dispenser, etc.) and the secret key contained in the card, and to supply in return to the host system this encrypted message, which allows for example the host system to authenticate the component or the card, to exchange data, etc.

However, it has turned out that these components or these cards are vulnerable to attacks consisting of a differential current consumption analysis and which allow ill-intentioned third parties to find the secret key. These attacks are referred to as DPA (*Differential Power Analysis*) attacks.

The principle of these DPA attacks is based on the fact that the current consumption of a microprocessor executing instructions varies according to the data manipulated.

Notably, an instruction of a microprocessor manipulating a data bit generates two different current profiles depending on whether this bit has the value "1" or "0". Typically, if the instruction is manipulating a "0", there is at that execution instant a first consumed current amplitude, and if the instruction is manipulating a "1", there is a second consumed current amplitude, different from the first.

The characteristics of cryptographic algorithms are known: the calculations performed and parameters used. The sole unknown is the secret key contained in program memory. This cannot be deduced from the sole knowledge of the message applied at the input and the encrypted message supplied in return.

However, in a cryptographic algorithm, certain calculated data depend solely on the message applied in clear at the input of the card and the secret key contained in the card. Other data calculated in the algorithm can also be recalculated solely from the encrypted message (generally supplied in clear at the

output of the card to the host system) and the secret key contained in the card. More precisely, each bit of these particular data items can be determined from the input or output message, and from a limited number of particular bits of the key.

Thus, each bit of a particular data item has corresponding thereto a sub-key formed by a particular group of bits of the key.

The bits of these particular data items which can be predicted are referred to in the remainder of the document as target bits.

The basic idea of the DPA attack is thus to use the difference in the current consumption profile of an instruction depending on whether it is manipulating a "1" or a "0" and the possibility of calculating a target bit by the instructions of the algorithm from a known input or output message and a hypothesis on the corresponding sub-key.

The principle of the DPA attack is therefore to test a given sub-key hypothesis by applying, to a large number of current measurement curves, each relating to an input message known to the attacker, a Boolean selection function, a function of the sub-key hypothesis, and defined for each curve by the value predicted for a target bit.

Making a hypothesis on the sub-key concerned in fact gives the capability of predicting the value "0" or "1" which this target bit will take for a given input or output message.

There can then be applied, as a Boolean selection function, the value "0" or "1" predicted for the target bit for the considered sub-key hypothesis, in order to sort these curves into two bundles: a first bundle groups together the curves where the target bit was manipulated at "0" and a second bundle groups together the curves where the target bit was manipulated at "1" according to the sub-key hypothesis. By calculating the current consumption mean in each bundle, a mean consumption curve $M_0(t)$ for the first bundle and a mean consumption curve $M_1(t)$ for the second bundle are obtained.

If the sub-key hypothesis is correct, the first bundle actually groups together all the curves among the N curves where the target bit was manipulated at "0" and the second bundle actually groups together all the curves among the N curves where the target bit was manipulated at "1". The mean consumption curve $M_0(t)$ of the first bundle will then have a mean consumption everywhere except at the moments at which the critical instructions are executed, with a current consumption profile characteristic of manipulation of the target bit at "0" ($profile_0$). In other words, for all these curves, all the manipulated bits had as many chances of having the value "0" as having the value "1", except the target bit which always had the value "0". This can be written:

$$M_0(t) = [(profile_0 + profile_1)/2]_{t \neq t_{ci}} + [profile_0]_{t_{ci}} \text{ that is} \\ M_0(t) = [Vm_t]_{t \neq t_{ci}} + [profile_0]_{t_{ci}}$$

where t_{ci} represents the critical instants, at which a critical instruction was executed.

Similarly, the mean consumption curve $M_1(t)$ of the second bundle corresponds to a mean consumption everywhere except at the moments at which the critical instructions are executed, with a current consumption profile characteristic of manipulation of the target bit at "1" ($profile_1$). The following can be written:

$$M_1(t) = [(profile_0 + profile_1)/2]_{t \neq t_{ci}} + [profile_1]_{t_{ci}} \text{ that is} \\ M_1(t) = [V_{m_t}]_{t \neq t_{ci}} + [profile_1]_{t_{ci}}$$

It has been seen that the two profiles $profile_0$ and $profile_1$ are not equal. The difference in the curves $M_0(t)$ and $M_1(t)$ then gives a signal $DPA(t)$, the amplitude of which is equal to $profile_0 - profile_1$ at the critical instants t_{ci} at which the critical instructions manipulating this bit are executed, that is to say, in the example depicted in Figure 1, at the locations t_{c0} to t_{c6} , and the amplitude of which is approximately equal to zero apart from the critical instants.

If the sub-key hypothesis is false, the sort does not correspond to reality. Statistically, there are then, in each bundle, as many curves where the target bit was actually manipulated at "0" as curves where the target bit was manipulated at "1". The resultant mean curve $M_0(t)$ is then situated around a mean value given by $(profile_0 + profile_1)/2 = V_m$, since, for each of the

curves, all the bits manipulated, including the target bit, have as many chances of having the value "0" as having the value "1".

The same reasoning on the second bundle leads to a mean current consumption curve $M_1(t)$, the amplitude of which is situated around a mean value given by $(profile_0 + profile_1)/2 = V_m$.

The signal $DPA(t)$ supplied by the difference $M_0(t) - M_1(t)$ is in this case substantially equal to zero. The signal $DPA(t)$ in the case of a false sub-key hypothesis is depicted in Figure 2.

Thus, the DPA attack exploits the difference in the current consumption profile during execution of an instruction according to the value of the manipulated bit, in order to carry out a current consumption curve sort according to a Boolean selection function for a given sub-key hypothesis. By carrying out a differential analysis of the mean current consumption between the two bundles of curves obtained, an information signal $DPA(t)$ is obtained.

Overall, the steps in a DPA attack then consist in:

- a - taking N random messages (for example N equal to 1000);
- b - making the card execute the algorithm for each of the N random messages, plotting the current consumption curve each time (measured on the power supply terminal of the component);
- c - making a hypothesis on a sub-key;

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Figure 2). It is necessary to return to step c - and make a new hypothesis on the sub-key.

If the hypothesis proves to be correct, the procedure can move to the evaluation of other sub-keys, until the key has been reconstructed as much as possible. For example, with a DES algorithm, use is made of a key of 64 bits, only 56 of which are useful. With a DPA attack, it is possible to reconstruct at least 48 bits of the 56 useful bits.

Two documents relating to the technological background are cited below. These are the documents NAKAO Y ET AL: "THE SECURITY OF AN RDES CRYPTOSYSTEM AGAINST LINEAR CRYPTANALYSIS", IEICE TRANSACTIONS ON FUNDAMENTALS OF ELECTRONICS, COMMUNICATIONS AND COMPUTER SCIENCES, JP, INSTITUTE OF ELECTRONICS INFORMATION AND COMM. ENG. TOKYO, vol. E79-A, no. 1, page 12-19 XP000558714 ISSN: 0916-8508, denoted D1 and WO 00 27068, denoted D2.

The document D1 relates to a cryptosystem using the DES in order to be made secure.

The document D2 relates to an electronic component implementing a secret key algorithm; the implementation of this algorithm comprises the use of first means from an input data item (E) in order to supply an output data item.

The aim of the present invention is to implement, in an electronic component, a countermeasure method against attacks by differential analysis which brings about a null signal DPA(t), even where the sub-key hypothesis is correct.

ART 2A ABNBT

In this way, nothing allows the correct sub-key hypothesis case to be distinguished from the false sub-key hypothesis cases. By means of this countermeasure, the electronic component is guarded against DPA attacks.

It is known through the French patent application FR 2 785 477 published on 5 May 2000, by the GEMPLUS company, the content of which in its entirety forms an integral part of the present application, that it is not sufficient to arrange that the signal $DPA(t)$ is null in relation to a given target bit.

This is because, if the value taken by a number of target bits of the same data item manipulated by the critical instructions is considered, the curves will have to be sorted, no longer into two bundles, but into a number of bundles. It is no longer a binary selection function. It can be shown that, by next grouping together these bundles in one way or another, a signal $DPA(t)$ can be obtained which is non-null in the case of a correct sub-key hypothesis, whereas it would have been null if a sort had been performed according to a binary selection function on a single target bit.

Let, for example, two target bits of the same data item be taken. These two target bits can take the following 2^2 values: "00", "01", "10" and "11".

By applying the selection function to the $N=1000$ measured current consumption curves, four bundles of curves are obtained. If the sort is correct, a first bundle of around 250 curves corresponds to the value

"00", a second bundle of around 250 curves corresponds to the value "01", a third bundle of around 250 curves corresponds to the value "10" and a fourth bundle of around 250 curves corresponds to the value "11".

If the first and fourth bundles are grouped together in a first group and the second and third bundles are grouped together in a second group, two groups which are not equivalent are obtained.

In the first group, the two bits have as many chances of having the value "00" as having the value "11". The mean value at the critical instants of all the consumption curves in this group can be written:

$$M1(t_{ci}) = [\text{consumption}("00") + \text{consumption}("11")]/2$$

In the second group, the two bits have as many chances of having the value "01" as having the value "10". The mean value at the critical instants of all the consumption curves in this group can be written:

$$M2(t_{ci}) = [\text{consumption}("01") + \text{consumption}("10")]/2$$

If the difference between these two means is calculated, a non-null signal $DPA(t)$ is obtained. In other words, the two groups whose mean consumptions are being compared do not have an equivalent content.

In the aforementioned French patent application, an attempt has been made to prevent any significant signal in the DPA attack sense being obtained. Whatever the number of target bits taken, whatever the

combination of bundles made for comparing the mean consumptions, the signal $DPA(t)$ will always be null. For this, it is necessary to obtain equivalent bundles, whatever the number of target bits considered.

The aforementioned French patent application, as a solution to these various technical problems, proposes the use of a random value in an EXCLUSIVE OR operation with at least some output data from calculation means used in the algorithm.

With the use of such a random value, the data manipulated by the critical instructions become unpredictable while having a correct result at the output of the algorithm.

In the invention, however, it was ascertained that attacks could still be carried out successfully at well-determined locations in the algorithm execution, notably at the input and output of the algorithm.

The object of the present invention is a countermeasure method in which these attacks are also made impossible. According to the invention, a second random value is used, applied to the input parameters of the cryptographic algorithm, in an EXCLUSIVE OR operation. This second random value propagates through the whole algorithm, so that the data which were not protected by the first random value are protected by the second.

Thus, according to the invention, depending on the location in the algorithm, the data are protected either by the first random value, or by the second, or by a combination of these two random values.

As characterised, the invention therefore relates to a countermeasure method in an electronic component implementing a secret key cryptographic algorithm, the implementation of which comprises a number of successive calculation cycles in order to supply, from first input data applied to the first cycle, final data at the output of the last cycle allowing the production of an encrypted message, each calculation cycle using calculation means for supplying an output data item from an input data item, said calculation means comprising the application of a first random value (u) in order to obtain at the output an unpredictable data item, characterised in that the method comprises the use of means of applying a second random value to said first input data, according to an EXCLUSIVE OR operation.

Other characteristics and advantages of the invention are detailed in the following description given as a guide and being in no way limitative and with reference to the accompanying drawings, in which:

- Figures 1 and 2, already described, depict the signal $DPA(t)$ which can be obtained in accordance with a hypothesis on a sub-key of the secret key K, according to a DPA attack;

- Figures 3 and 4 are detailed flow diagrams of the first and last cycles of the DES algorithm, according to the state of the art;

- Figure 5 is a block diagram of the operation SBOX used in the DES algorithm as presented in Figures 3 and 4;

- Figure 6 shows an example elementary constants table with one input and one output used in the operation SBOX depicted in Figure 5;

- Figures 7 and 8 depict respectively an execution flow diagram of the DES and a detailed flow diagram of the first cycles, corresponding to an example application of the countermeasure method according to the state of the art;

- Figure 9 depicts an execution flow diagram of the DES according to the invention; and

- Figure 10 depicts a simplified block diagram of a smart card having an electronic component in which the countermeasure method according to the invention is implemented.

For a good understanding of the invention, the normal DES secret key cryptographic algorithm, with no countermeasure method, will first be described. This DES algorithm has 16 calculation cycles, denoted T1 to T16, as depicted in Figures 3 and 4.

The DES starts with an initial permutation IP on the input message M (Figure 3). The input message M is a 64-bit word f. After permutation, a 64-bit word e is obtained, which is cut into two in order to form the input parameters L0 and R0 of the first cycle (T1). L0 is a 32-bit word d containing the most significant 32 bits of the word e. R0 is a 32-bit word h containing the least significant 32 bits of the word e.

The secret key K, which is a 64-bit word q, itself undergoes a permutation and a compression in order to supply a 56-bit word r.

The first cycle comprises an operation EXP PERM on the parameter R0, consisting of an expansion and a permutation, in order to supply at the output a 48-bit word l.

This word l is combined with a parameter K1, in an EXCLUSIVE OR type operation denoted XOR, in order to supply a 48-bit word b. The parameter K1, which is a 48-bit word m, is obtained from the word r by a shift of one position (the operation denoted SHIFT in Figures 3 and 4) followed by a permutation and a compression (the operation denoted COMP PERM).

The word b is applied to an operation denoted SBOX, at the output of which a 32-bit word a is obtained. This particular operation will be explained in more detail in connection with Figures 5 and 6.

The word a undergoes a permutation P PERM, giving at the output the 32-bit word c.

This word c is combined with the input parameter L0 of the first cycle T1, in an EXCLUSIVE OR type logical operation, denoted XOR, which supplies at the output the 32-bit word g.

The word h (= R0) of the first cycle supplies the input parameter L1 of the next cycle (T2) and the word g of the first cycle supplies the input parameter R1 of the next cycle. The word p of the first cycle supplies the input r of the next cycle.

The other cycles T2 to T16 progress in a similar manner, except as regards the shift operation SHIFT which is carried out over one or two positions depending on the cycles considered.

Each cycle T_i thus receives at the input the parameters L_{i-1} , R_{i-1} and r and supplies at the output the parameters L_i and R_i and r for the next cycle T_{i+1} .

At the end of the DES algorithm (Figure 4), the encrypted message is calculated from the parameters L_{16} and R_{16} supplied by the last cycle T_{16} .

This calculation of the encrypted message C in practice comprises the following operations:

- formation of a 64-bit word e' by reversing the position of the words L_{16} and R_{16} , and then concatenating them;

- application of the permutation IP^{-1} , the inverse of that of the DES start, in order to obtain the 64-bit word f' forming the encrypted message C .

The operation SBOX is detailed in Figures 5 and 6. It comprises a constants table TC_0 for supplying an output data item a as a function of an input data item b .

In practice, this constants table TC_0 comes in the form of eight elementary constants tables TC_{01} to TC_{08} , each receiving at the input only 6 bits of the word b , for supplying at the output only 4 bits of the word a .

Thus, the elementary constants table TC_{01} depicted in Figure 6 receives, as input data, the bits b_1 to b_6 of the word b and supplies, as output data, the bits a_1 to a_4 of the word a .

In practice these eight elementary constants tables TC_{01} to TC_{08} are stored in the program memory of the electronic component.

In the operation SBOX of the first cycle T1, a particular bit of the output data a of the constants table TC₀ depends on solely 6 bits of the data b applied at the input, that is to say on solely 6 bits of the secret key K and the input message (M).

In the operation SBOX of the last cycle T16, a particular bit of the output data a of the constants table TC₀ can be recalculated from solely 6 bits of the secret key K and the encrypted message (C).

However, going back to the principle of the DPA attack, if one or more bits of the output data a are chosen as target bits, it is sufficient to make a hypothesis on 6 bits of the key K in order to predict the value of the target bit or bits for a given input message (M) or output message (C). In other words, for the DES, it is sufficient to make a hypothesis on a 6-bit sub-key.

In a DPA attack on such an algorithm for a given set of target bits issuing from a given elementary constants table, a correct sub-key hypothesis has therefore to be distinguished from among 64 possible ones.

Thus, from the output bits of the eight elementary constants tables TC₀₁ to TC₀₈, up to $8 \times 6 = 48$ bits of the secret key can be discovered, by carrying out DPA attacks on corresponding target bits.

In the DES, critical instructions in the DPA attack sense are therefore found at the start of the algorithm and at the end. These instructions are

detailed in the French patent application FR 98 13605 to which reference can usefully be made.

And it emerges that all the data manipulated by critical instructions are an output data item or data derived from an output data item of a DES start and end SBOX operation.

The countermeasure method described in the aforementioned French patent application applied to this DES algorithm consists of making each of the data items manipulated by the critical instructions unpredictable. Thus, whatever the target bit or bits used, the signal $DPA(t)$ will always be null. This countermeasure method is applied to the DES start critical instructions and to the DES end critical instructions.

By taking the SBOX operations as first calculation means for supplying an output data item $S=a$ from an input data item $E=b$, the countermeasure method of the aforementioned French patent application applied to the DES algorithm consists of using other calculation means instead of the first, in order to make the output data item unpredictable, so that this output data item and/or derived data manipulated by the critical instructions are all unpredictable.

These other means can comprise various means. They are calculated from the first means by applying an EXCLUSIVE OR with a random value u (or a derived random value) to one and/or the other of the input and output data of the first means.

The use of this random value u is such that the result at the output of the algorithm, that is to say, the encrypted message C , remains correct.

Figures 7 and 8 depict an example application of this countermeasure method, which corresponds to Figure 10 of the aforementioned French patent application.

In a conventional execution of the DES algorithm, it has been seen that each cycle comprises the use of first means TC_0 in an operation SBOX.

In this example, and as depicted in Figure 7, other means are calculated by performing an EXCLUSIVE OR with a random value u on the output data of the first means TC_0 and by performing an EXCLUSIVE OR with a derived value $e(p(u))$ on the input data of the first means TC_0 . Then an identical execution sequence SEQ_A is applied to each group, which consists in using these other calculated means.

In this method, use is therefore made of a random value u which is a 32-bit data item. For example, a 32-bit random value can be taken, or else a 4-bit random value can be taken and copied 8 times in order to obtain a 32-bit random value.

The derived variable equal to $e(p(u))$ is then calculated, where $p(u)$ corresponds to the result of the operation P PERM applied to the value u and where $e(p(u))$ is the result of the operation EXP PERM applied to the value $p(u)$.

The other means used by this countermeasure method can then be calculated.

In the example depicted with reference to Figure 7, these other means comprise second means TC_2 with an additional EXCLUSIVE OR operation denoted CP.

The second means TC_2 are used in each of the cycles.

They are calculated by applying an EXCLUSIVE OR with the derived random variable $e(p(u))$ to the input data E and applying an EXCLUSIVE OR with the random value u to the output data S of the first means TC_0 , which can be written:

$$TC_2 = (E \oplus e(p(u)), S \oplus u).$$

The additional EXCLUSIVE OR operation CP with the derived random variable $e(p(u))$ makes it possible to obtain, at the input of the second means TC_2 , the data $b \oplus e(p(u))$. This operation is denoted $CP(e(p(u)))$ in Figures 7 and 8.

This additional EXCLUSIVE OR operation CP with the variable $e(p(u))$ can be placed in various locations in the first and last cycles, either between the operation EXP PERM and the operation XOR or between the operation XOR and the operation SBOX. It can be replaced by an additional EXCLUSIVE OR operation CP with the derived random variable $p(u)$, by placing this additional operation $CP(p(u))$ before the operation EXP PERM. $l \oplus e(p(u))$ is obtained at the output, and this will therefore then give $b \oplus e(p(u))$.

In all these cases, the data $b \oplus e(p(u))$ is obtained at the input of the operation SBOX.

The calculation program then consists, at the start of execution of the algorithm, in taking a random value u , in the example a 4-bit value, of calculating the derived random variable $e(p(u))$, and then of calculating the various means used in the execution sequence SEQA, that is to say calculating the second means TC_2 .

At the output of each group, the correct result for the output parameters is obtained. Thus, the output parameters L_4 and R_4 of the first group G_1 , L_8 and R_8 of the second group G_2 , L_{12} and R_{12} of the third group G_3 , and L_{16} and R_{16} of the fourth group G_4 are correct whatever the random variable taken.

When all the cycles have been performed, the correct parameters L_{16} and R_{16} are obtained which will make it possible to calculate the correct encrypted message C .

On the other hand, within the groups, certain intermediate results do not have the same values according to the sequence used, but values corresponding to the EXCLUSIVE OR operation with the random value u or with the derived random value $e(p(u))$, which makes it possible to obtain protection against DPA attacks.

Figure 8 shows the detailed flow diagram of the four cycles T_1 , T_2 , T_3 and T_4 of the first group G_1 , in the sequence SEQA, which makes it possible to reveal the role of the second means TC_2 used in each cycle. According to their definition: $TC_2 = E \oplus e(p(u))$, $S \oplus u$; by applying at the input the randomly modified data

ART 34 AMDT

$b \oplus e(p(u))$ by means of the additional operation CP, the randomly modified data $a \oplus u$ is obtained at the output. Taking this reasoning from the cycle T1 to the end of the cycle T4, and noting that $p(u) \oplus p(u) = 0$, the unmodified data L4, R4 are obtained at the output of the cycle T4.

With such a countermeasure method, taking of the random value u and calculation of the means used in the execution sequence SEQA must be provided at the DES start. These means, calculated at each execution of the DES, are stored, at execution time, in working memory, the first means TC_0 which are used for the calculation being themselves stored in program memory.

This countermeasure method according to the state of the art, which therefore consists in general terms in applying a random value u at least to the output of the calculation means used in each cycle of the algorithm, leaves certain data in clear. In Figures 7 and 8 it can be seen that the input data, L0, R0, and following them the data h, l and b of the first cycle, are used in clear.

Similarly, the data R3, L4, R4, R7, L8, R8, R11, L12, R12, R15, L16 and R16 are used in clear.

In general terms, whatever the mode of application of the countermeasure method of the state of the art which has just been described, at least the input data L0 and R0 and output data L16 and R16 are used in clear in the algorithm. Other intermediate data may be so, as in the case described previously, which depend more particularly on the considered mode

of application of the countermeasure method of the state of the art, of which Figures 7 and 8 show only one of the example applications.

In practice, attacks can therefore still be carried out on the algorithm, based on these data used in clear.

The present invention therefore proposes an improvement to the aforementioned countermeasure method, which makes it possible to make all the data used in the algorithm unpredictable, by means of either the first random value u , or a second random value denoted v , or a combination of the two.

An example implementation of this method is depicted in Figure 9.

According to the invention, a second random value denoted v is used, applied to the input data $L0$ and $R0$, by means of an EXCLUSIVE OR operation.

Thus, the input data actually used in the calculation of the algorithm are unpredictable data equal to $L0 \oplus v$ and $R0 \oplus v$.

This second random value propagates through each of the cycles of the algorithm. At the output of the sixteenth cycle $T16$, the unpredictable data equal to $L16 \oplus v$ and $R16 \oplus v$ are therefore obtained as output data.

In order to rediscover the true output data $L16$ and $R16$ which will make it possible to obtain the encrypted message C , an EXCLUSIVE OR operation with the second random value v is applied to each of these data items $L16 \oplus v$ and $R16 \oplus v$.

The use of the two random values u and v in combination makes it possible to obtain an improved countermeasure method, making the DES algorithm which implements it impervious to attack.

Figure 9 shows the detail of a practical example implementation of a countermeasure method according to the invention.

If the first cycle T_1 is taken, there are at the input the data items $L \oplus v$ and $R \oplus v$ to which the operations EXP PERM and XOR (with the key K_1) are applied successively. The data at the input of the next operation SBOX is therefore the data $b \oplus v$.

The calculation means TC_M associated with this operation SBOX consist, as in the countermeasure method of the state of the art, of a constants table deduced from the original constants table TC_0 of the DES algorithm.

Denoting this original constants table $TC_0 = (E, S)$ as seen in connection with Figure 6, the new calculation means TC_M are calculated as follows:

$$TC_M = (E \oplus e(v), S \oplus u).$$

In this way, the second random value v applied to the data at the input of each cycle is taken into account, and benefit is still obtained from the first random value, u , according to the method of the state of the art, at the output of the operation SBOX.

Thus, at the output of the operation SBOX using the calculation means TC_M , the data $a \oplus p(u)$ is obtained,

to which the operation P PERM is applied, giving the data $c \oplus p(u)$.

The following XOR operation with the input data $L0 \oplus v$ supplies at the output the data $g \oplus p(u) \oplus v$.

It should be noted that, in the state of the art described (Fig. 8), at this stage the data $g \oplus p(u)$ used at the input of the second cycle $T2$ was obtained.

With the method according to the invention, the other input of the second cycle is the data $L1 \oplus v = R0 \oplus v$, as shown in Figure 9.

The second random value v therefore propagates through all the cycles of the algorithm.

If the random value u is not eliminated from the output data of the first cycle ($R1 \oplus (v) \oplus p(u)$), it is necessary to make provision for the use of other calculation means TC_M' in the second cycle $T2$, defined by $TC_M' = E \oplus e(v) \oplus e(p(u))$, $S \oplus u$.

This implementation of the invention is not of great interest, since it necessitates the calculation of two new constants tables TC_M and TC_M' , the random value u being applied in the table TC_M' , not only to the output, but also to the input.

Also, according to the invention, and as depicted in Figure 9, in order to facilitate the use of the two random variables u and v by reducing the calculations necessary for its implementation and in order to repeat the same operations in each cycle, an additional EXCLUSIVE OR operation denoted $CP(p(u))$ is provided at the end of each cycle, so as to eliminate the value

$p(u)$ at the input of each new cycle. Thus, at the input of the second cycle $T1$, the data $R1 \oplus v = (g \oplus p(u) \oplus v) \oplus p(u)$ is obtained, that is

$$R1 \oplus v = g \oplus v.$$

Each cycle then follows the previous one, executing the same sequence of calculation operations, so that, at the output of the sixteenth cycle, $L16 \oplus v$ and $R16 \oplus v$ are obtained as output data. By applying an EXCLUSIVE OR operation with the second random value v to each of these two data items, the data $L16$ and $R16$ are obtained which allow the encrypted message C to be produced.

By applying the countermeasure method according to the invention which combines the use of a first random value u in calculation means provided in each cycle and the use of a second random value applied at the input, before the execution of the first cycle, all the data used in the algorithm are made unpredictable. Depending on the location in the algorithm, the countermeasure protection according to the invention is provided either by the first random value u , or by the second random value v , or by a combination of these two values.

In practice, and in the example application depicted in Figure 9, before executing the DES algorithm proper, it is necessary to execute the following operations:

- taking of the random values u and v
- calculation of $p(u)$ for the operation $CP(p(u))$

- calculation of $e(v)$
- calculation of $TC_M = E \oplus e(v)$, $S \oplus u$.

The random value v is a data item having the same number of bits as the data items $L0$ and $R0$, that is 32 bits in the example. In this method, use is therefore made of a random value v which is a 32-bit data item. For example, a 32-bit random value can be taken, or else a 4-bit random value can be taken and copied 8 times in order to obtain a 32-bit random value (as for the random value u).

Other example applications can be envisaged, in which notably it can be provided that the cycles are not identical. All these variants which use the two random values according to the general principle explained are within the scope of the invention.

An electronic component 1 implementing a countermeasure method according to the invention in a DES secret key cryptographic algorithm comprises typically, as depicted in Figure 10, a microprocessor mP, a program memory 2 and a working memory 3. The various calculation means TC_0 and TC_M are, in practice, constants tables stored respectively in program memory 1 and in working memory 3. In order to be able to manage the use of these calculation means, means 4 of generating a random value are provided which, if reference is made to the flow diagrams of Figures 7 and 11, will supply the random values u and v at each execution of the DES. Such a component can most particularly be used in a smart card 5, in order to improve its inviolability.

CLAIMS

1. A countermeasure method against attacks by differential analysis in an electronic component implementing a secret key (K) cryptographic algorithm, the implementation of which comprises a number of successive calculation cycles (T1, ... T16) in order to supply, from first input data (L0, R0) applied to the first cycle (T1), final data (L16, R16) at the output of the last cycle (T16) allowing the production of an encrypted message (C), each calculation cycle using calculation means (TC) for supplying an output data item (S) from an input data item (E), said calculation means comprising the application of a first random value (u) to the input data item (E) and to the output data item (S) in order to obtain at the output an unpredictable data item ($S \oplus u$), characterised in that the method comprises the use of means of applying a second random value (v) to said first input data (L0, R0), according to an EXCLUSIVE OR operation.

2. A countermeasure method according to Claim 1, characterised in that it also comprises the use of means of applying the second random value (v) to the final data supplied by the last cycle (T16), according to an EXCLUSIVE OR operation.

3. A countermeasure method according to either one of the previous claims, characterised in that it comprises, at the end of each cycle, the execution of an additional operation ($CP(p(u))$) in order to

eliminate said first random value (u) at the output of each cycle.

4. A countermeasure method according to any one of the previous claims, characterised in that it comprises the taking of first and second random values (u , v) and calculation of the calculation means (TC_M) used in each cycle for each new execution of the algorithm.

5. A method according to Claim 4, characterised in that said calculation means (TC_M) are calculated from first calculation means (TC_0) defining, for input data (E), corresponding output data (S), by applying the second random value (v) to said input data ($E \oplus v$) and applying the first random value (u) at least to said output data ($S \oplus u$) of the first calculation means.

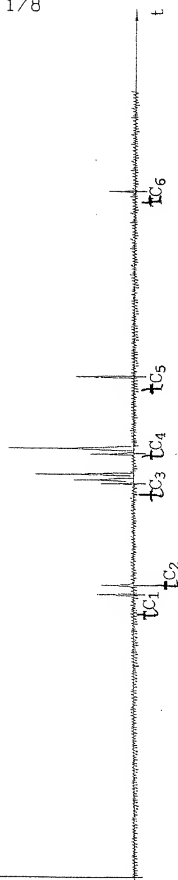
6. A countermeasure method according to Claim 5, characterised in that the calculation means (TC_0 , TC_M) are constants tables.

7. An electronic security component implementing the countermeasure method against attacks by differential analysis comprising a secret key (K) cryptographic algorithm, the implementation of which comprises a number of successive calculation cycles ($T1$, ... $T16$) in order to supply, from first input data ($L0$, $R0$) applied to the first cycle ($T1$), final data ($L16$, $R16$) at the output of the last cycle ($T16$) allowing the production of an encrypted message (C), each calculation cycle using calculation means (TC) for supplying an output data item (S) from an input data item (E), said calculation means comprising the

application of a first random value (u) to the input data item (E) and to the output data item (S) in order to obtain at the output an unpredictable data item ($S \oplus u$), characterised in that first calculation means (TC_0) are fixed in program memory (1) of said component, calculation means (TC_M) used in each cycle being calculated at each new execution of the algorithm and stored in working memory (3), and in that it comprises means (4) of generating first and second random values (u, v) for calculating said calculation means (TC_M).

8. A smart card comprising an electronic security component according to Claim 7.

1/8

FIG.1 $DPA(t)$ 

2/8

FIG.2 $DPA(t)$ t

3/8

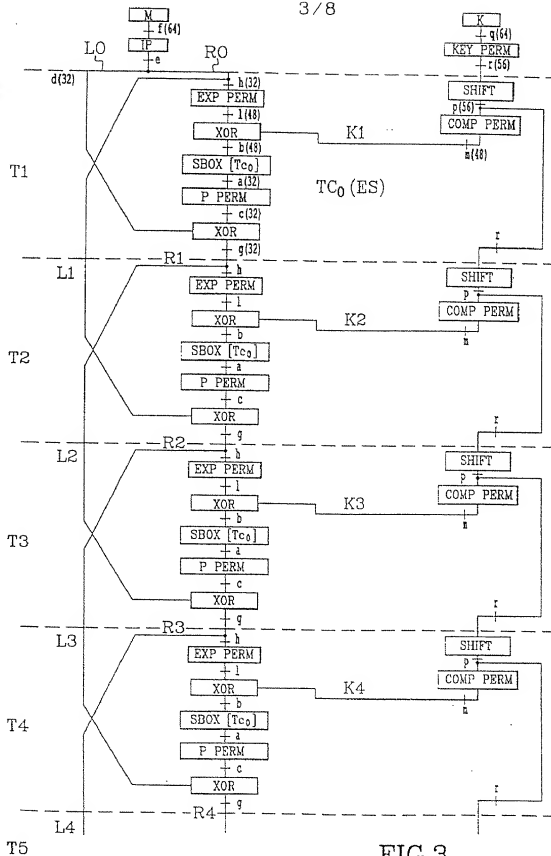


FIG.3

4/8

T12

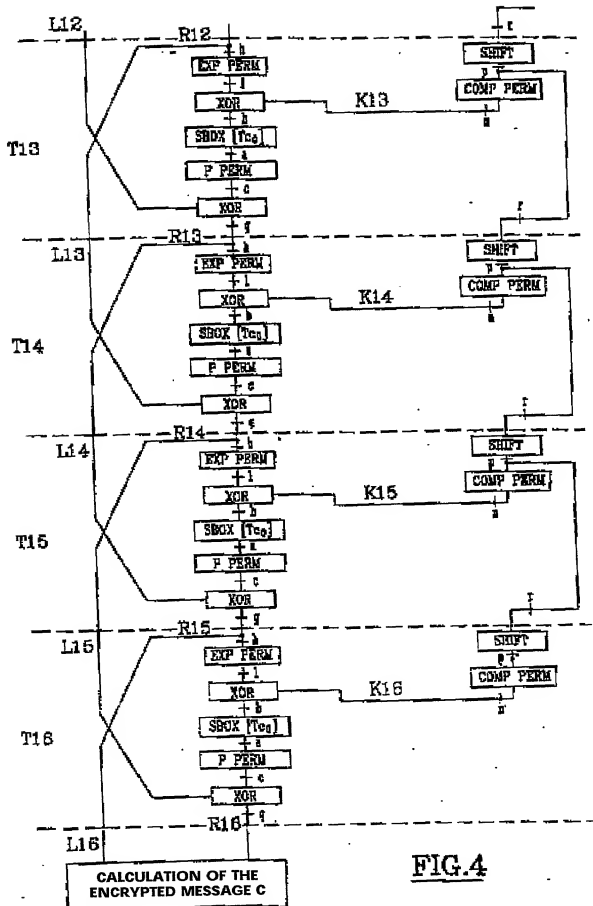
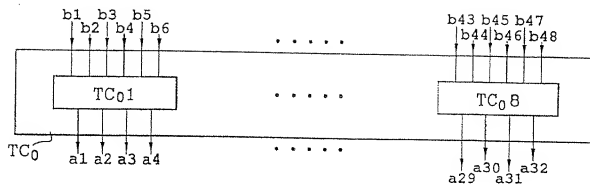


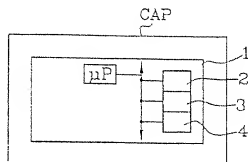
FIG.4

5/8

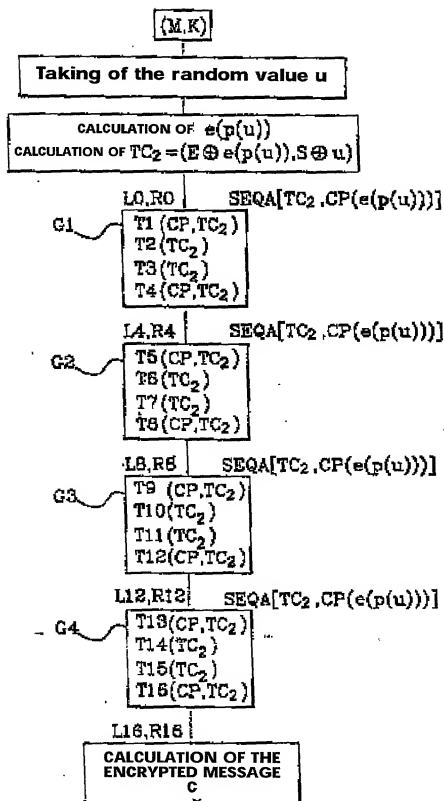
FIG. 5

TC0 1

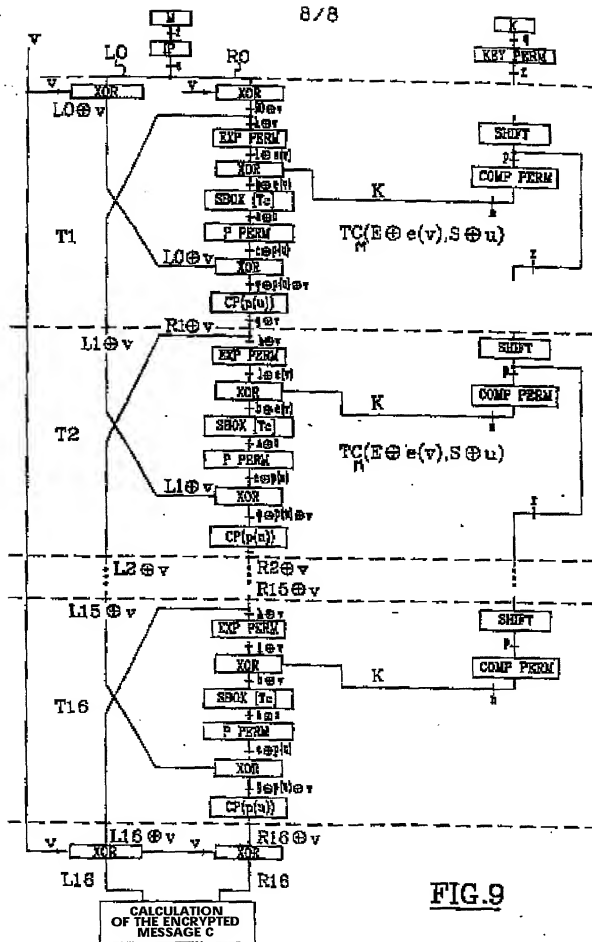
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000000	1101
000001	0101
⋮	⋮
111111	1010

FIG. 6FIG. 10

6/8

**FIG. 7**

8/8



CE0170

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY (Includes Reference to Provisional and International (PCT) Applications)	Attorney's Docket No. 032326-165
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As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;
 I BELIEVE I AM THE ORIGINAL, FIRST AND SOLE INVENTOR (IF ONLY ONE NAME IS LISTED BELOW) OR AN ORIGINAL, FIRST AND JOINT INVENTOR (IF PLURAL NAMES ARE LISTED BELOW) OF THE SUBJECT MATTER WHICH IS CLAIMED AND FOR WHICH A PATENT IS SOUGHT ON THE INVENTION ENTITLED:

COUNTERMEASURE METHOD IN AN ELECTRIC COMPONENT USING A SECRET KEY CRYPTOGRAPHIC ALGORITHM

The specification of which (check only one item below):

- ☐ is attached hereto,
 was filed as United States Patent Application Number _____
 on _____ and was amended on _____ (if applicable).
☒ was filed as International (PCT) Application Number **PCT/FR00/00283**
 on **February 07, 2000**
 and was amended on _____ (if applicable).

I HAVE REVIEWED AND UNDERSTAND THE CONTENTS OF THE ABOVE-IDENTIFIED SPECIFICATION, INCLUDING THE CLAIMS, AS AMENDED BY ANY AMENDMENT REFERRED TO ABOVE.

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I do not know and do not believe the said invention was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to said application; that said invention was not in public use or on sale in the United States of America more than one year prior to said application; that said invention has not been patented or made the subject of an inventor's certificate issued before the date of said application in any country foreign to the United States of America on any application filed by me or my legal representatives or assigns more than six months prior to said application;

I hereby claim foreign priority benefits under Title 35, United States Code, §§ 119 (a)-(e) of any foreign application(s) for patent or inventor's certificate or of any International (PCT) Application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT International (PCT) Application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. §119:

COUNTRY (if PCT, indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 U.S.C. §119
FRANCE	99/02834	March 08, 1999	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No

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(APPLICATION NUMBER) (FILING DATE)

(APPLICATION NUMBER) (FILING DATE)

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY (CONT'D)
(Includes Reference to Provisional and International (PCT) Applications)

Attorney's Docket
 No. 032326-165

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) or International (PCT) Application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to the patentability as defined in Title 37, Code of Federal Regulations § 1.56, which became available between the filing date of the prior application(s) and the national or international filing date of this application:

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U.S. APPLICATIONS		STATUS (check one)		
U.S. APPLICATION NUMBER	U.S. FILING DATE	PATENTED	PENDING	ABANDONED
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
PCT APPLICATIONS DESIGNATING THE U.S.				
PCT APPLICATION NO.	PCT FILING DATE	U.S. APPLICATION NUMBERS ASSIGNED (if any)		
PCT/FR00/00283	February 07, 2000			

I hereby appoint the following attorneys and agent(s) to prosecute said application and to transact all business in the U.S. Patent and Trademark Office connected therewith and to file, prosecute and to transact all business in connection with international applications directed to said invention:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY (CONT'D) (Includes Reference to Provisional and International (PCT) Applications)		Attorney's Docket No. 032326-165	
FULL NAME OF SOLE OR FIRST INVENTOR BENOIT OLIVIER		SIGNATURE <i>[Signature]</i> DATE 03/10/2001	
RESIDENCE (CITY & STATE/COUNTRY) LA TREILLE D'AZUR, BATIMENT D, 13400 AUBAGNE / FRANCE <i>FKV</i>		CITIZENSHIP FRANCE	
POST OFFICE ADDRESS (HOME ADDRESS) LA TREILLE D'AZUR, BATIMENT D, 13400 AUBAGNE / FRANCE			
FULL NAME OF SECOND JOINT INVENTOR, IF ANY		SIGNATURE DATE	
RESIDENCE (CITY & STATE/COUNTRY)		CITIZENSHIP	
POST OFFICE ADDRESS (HOME ADDRESS)			
FULL NAME OF THIRD JOINT INVENTOR, IF ANY		SIGNATURE DATE	
RESIDENCE (CITY & STATE/COUNTRY)		CITIZENSHIP	
POST OFFICE ADDRESS (HOME ADDRESS)			
FULL NAME OF FOURTH JOINT INVENTOR, IF ANY		SIGNATURE DATE	
RESIDENCE (CITY & STATE/COUNTRY)		CITIZENSHIP	
POST OFFICE ADDRESS (HOME ADDRESS)			
FULL NAME OF FIFTH JOINT INVENTOR, IF ANY		SIGNATURE DATE	
RESIDENCE (CITY & STATE/COUNTRY)		CITIZENSHIP	
POST OFFICE ADDRESS (HOME ADDRESS)			
FULL NAME OF SIXTH JOINT INVENTOR, IF ANY		SIGNATURE DATE	
RESIDENCE (CITY & STATE/COUNTRY)		CITIZENSHIP	
POST OFFICE ADDRESS (HOME ADDRESS)			
FULL NAME OF SEVENTH JOINT INVENTOR, IF ANY		SIGNATURE DATE	
RESIDENCE (CITY & STATE/COUNTRY)		CITIZENSHIP	
POST OFFICE ADDRESS (HOME ADDRESS)			
FULL NAME OF EIGHTH JOINT INVENTOR, IF ANY		SIGNATURE DATE	
RESIDENCE (CITY & STATE/COUNTRY)		CITIZENSHIP	
POST OFFICE ADDRESS (HOME ADDRESS)			
FULL NAME OF NINTH JOINT INVENTOR, IF ANY		SIGNATURE DATE	
RESIDENCE (CITY & STATE/COUNTRY)		CITIZENSHIP	
POST OFFICE ADDRESS (HOME ADDRESS)			
FULL NAME OF TENTH JOINT INVENTOR, IF ANY		SIGNATURE DATE	
RESIDENCE (CITY & STATE/COUNTRY)		CITIZENSHIP	
POST OFFICE ADDRESS (HOME ADDRESS)			